Speckle Patterns with Atomic and Molecular de Broglie Waves

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The burgeoning interest in coherent x-ray beams motivates consideration of other kinds of particle beams with adequate brightness to allow a comparable suite of experiments. For example, high brightness field emission sources enable electron microscopes to utilize transverse coherence in various imaging applications. Atomic coherence is an integral part of the Bose-Einstein condensation in atom traps, and this coherence is increasingly used in many novel applications – though none very similar to those being developed in the x-ray regime.

We have developed a free-jet nozzle source that delivers a continuous beam of atomic helium or molecular hydrogen having a high degree of transverse coherence and with an optical brightness about a factor of 100 lower than an x-ray undulator at a third generation synchrotron radiation facility. The de Broglie wavelength of ~1 Å suggests applications similar to those being developed using coherent x-ray beams – phase retrieval and imaging, correlation spectroscopy, speckle metrology, etc. Using this source we have measured single slit diffraction patterns and the first ever speckle-diffraction patterns using atomic and molecular de Broglie waves. Our results suggest fruitful application of coherent matter beams at short wavelength, with extreme surface sensitivity, and with essentially no sample damage.